Feeding habits of *Calma glaucoides* (Alder & Hancock, 1854): its adaptive structures and behaviour

Gonçalo Calado [1,2] *& Victoriano Urgorri* [2]

KEY WORDS: Aeolidacea; *Calma glaucoides*; Feeding

ABSTRACT *Calma glaucoides* (Alder & Hancock, 1854) is an aeolid nudibranch inhabiting European (Atlantic and Mediterranean) Western and Southern coasts. Adults feed on fish eggs, thus being found near spawning sites on the underside of boulders or in small crevices, where male fish nest. This aeolid has an atypical uniseriate radula. Little is known about formation or function of this radula, but it is believed that such a peculiar morphology is related to adult's feeding habits. The feeding behaviour of individuals could be observed in aquaria. It was also possible to study not only radulae from individuals of different sizes but also the damage caused by radula action upon fish egg membranes. These were visible under SEM after critical point drying of empty eggs. SEM images suggest that the radula is used as a saw. After the egg is "opened" the yolk and embryo are sucked out with the help of strong buccal musculature, leaving the external membrane of the egg almost intact. The way these animals puncture fish eggs, associated with the early development of their radula, lead us to conclude, that there seems to be no food size constraint, as previously had been thought.

RIASSUNTO *Calma glaucoides* (Alder & Hancock, 1854) è un eolidiaceo presente lungo le coste dell'Atlantico occidentale e del mediterraneo. L'adulto si nutre di uova di pesci e viene spesso ritrovato vicino alle ovature, sul lato inferiore dei massi o in piccole fessure della roccia. Questo eolidiaceo ha una radula uniseriata molto atipica. Poco conosciute sono la sua formazione e funzione, ma si pensa che la tipica morfologia debba essere correlata al comportamento trofico della specie. Grazie al mantenimento di alcuni esemplari in acquario, è stato possibile studiare il comportamento di questa specie, la morfologia radulare in individui di diversa taglia e i danni causati dalla radula stessa sulla membrana delle uova dei pesci. Immagini al SEM, dopo il critical point, delle uova indicano che la radula viene usata come una sega. Dopo che l'uovo è stato tagliato, il tuorlo e l'embrione vengono risucchiati grazie all'azione di una forte muscolatura, lasciando praticamente intatta la membrana esterna dell'uovo. Il modo con cui questi nudibranchi tagliano le uova, in rapporto anche al primo sviluppo della radula, suggerisce che la taglia dell euova non sia un fattore limitante, come precedentemente supposto.

G. CALADO, V. URGORRI
[1] Instituto Português de Malacologia, Apartado No. 52, S. Pedro do Estoril, 2766-501 Estoril, Portugal. E-mail: bacongas@mail.telepac.it
[2] Laboratorio de Zooloxía Mariña, Departamento de Bioloxía Animal, Universidade de Santiago de Compostela, 15706 Santiago de Compostela, Spain.

INTRODUCTION

Most aeolid nudibranchs feed on cnidarians and therefore they possess strong jaws and uniseriate or triseriate radulae, with few exceptions in both characteristics. *Calma glaucoides* (Alder & Hancock, 1854), an aeolid nudibranch inhabiting European (Atlantic and Mediterranean) Western and Southern coasts, is precisely one such exception. Adults (7 to 18 mm) are found on their food supply, the spawn of teleost fishes such as *Lepadogaster lepadogaster*, *Lepadogaster candollei*, *Parablennius gattorugine* and *Parablennius pilicornis,* which deposit their eggs on the underside of boulders or empty bivalve shells. *C. glaucoides* has a very atypical "uniseriate" radula, previously described as a row of very small teeth and a group of few bigger teeth at the distal end. Little is known about the formation or function of this radula, but it is believed that such a peculiar morphology is related with adult's feeding habits (Evans, 1922; Rowett, 1946). The extent of such a relation is the subject matter of this study.

MATERIALS AND METHODS

We worked with specimens obtained from the Iberian Atlantic Coast (Galicia – NW Spain (43° 27' N, 8° 16' W) and Arrábida, Portugal (38° 27' N, 9° 0' W)). They were preserved in 70% ethanol. Buccal masses were extracted and placed in a 5% NaOH solution for 24 h at 40° C. When radulae were detached they were abundantly rinsed in tap water. Six radulae for SEM were dried and coated with gold prior to examination.

In order to observe their feeding behaviour, three recently collected individuals of *C. glaucoides* were kept in small beakers with small stones containing portions of *Parablennius pilicornis* spawn. After consumption of the egg contents, empty egg membranes were dehydrated in alcohol, and observed in SEM after critical point treatment.

RESULTS

Radular morphology

SEM images allowed a closer examination of seemingly important details. Small teeth of the serration measure about 1mm (Fig. 1) and in high magnification (top image) it is possible to see some erosion on their outer edges (Fig. 2). In small animals, the first-formed "big" teeth were smaller than in later ones, as if they were in formation after differentiation of the distal edges. Radula size differs relating little between animals having a body length of 1.4 mm from those of 2.5 mm (Fig. 3). This suggests that the radular morphology, developed early in the ontogeny, is preserved throughout adult life. Similar arrested morphological development of the radula is known, for example, from the Harpidae (Hughes & Emerson, 1987).

Feeding behaviour

In order to consume an egg, *Calma glaucoides* crawls over the fish spawn. Then it proceeds to enwrap an egg with its oral tentacles; immediately afterwards we can see, through the almost transparent body, the egg contents being sucked in and rapidly moved along the oesophagus to the stomach. During the feeding process,

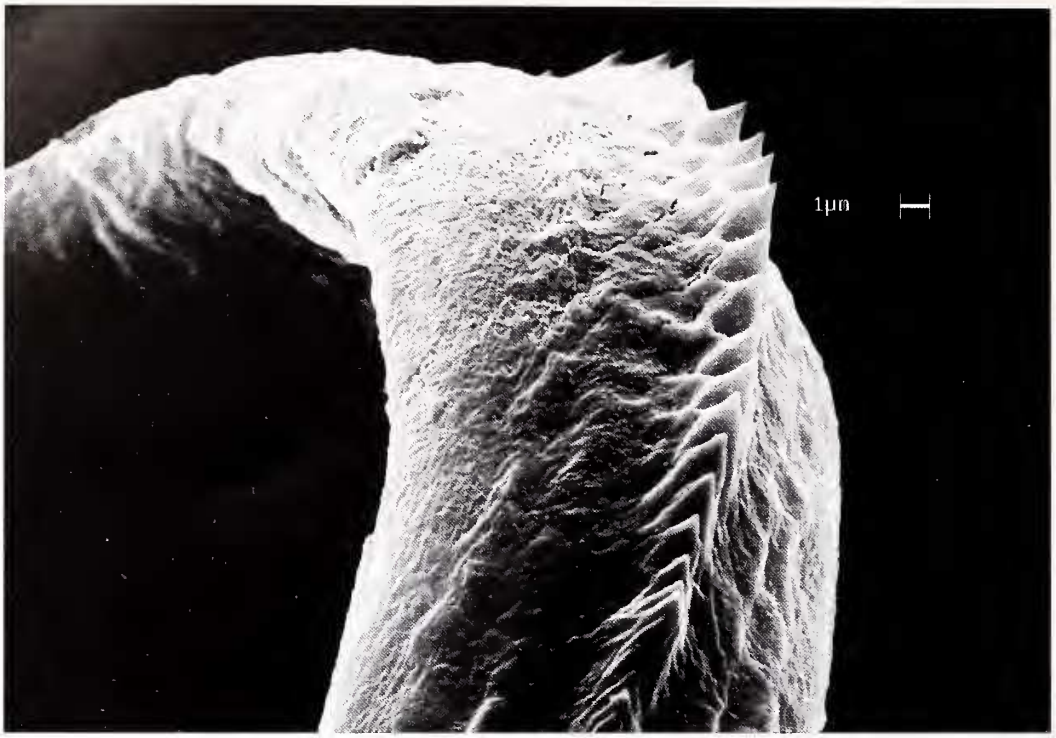

Fig. 1 - SEM picture of a radula where saw-like teeth are visible.
Fig. 2 – Top image of serrated bar with saw-like teeth.

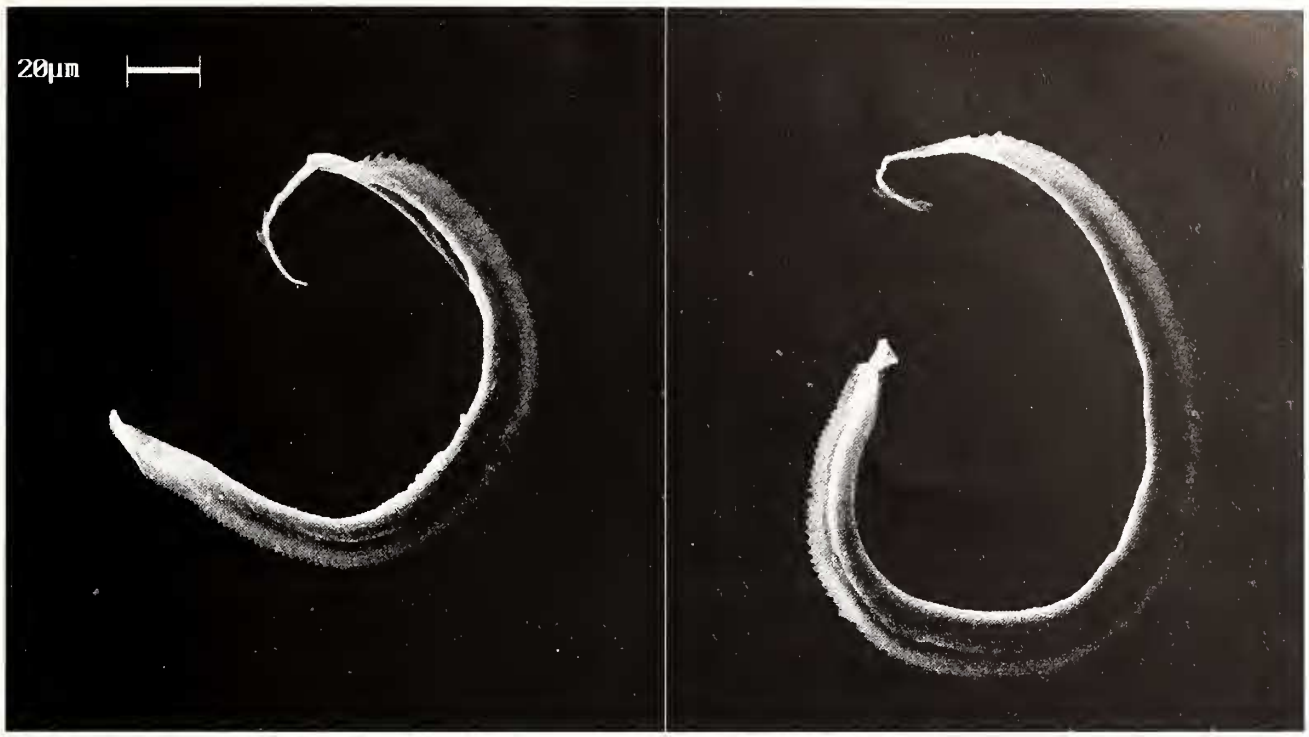

Fig. 3 - SEM views of two radulae. Left: from a 1.4 mm long specimen. Right: from a 2.5 mm long specimen. Scale bar for both pictures.
Fig. 4 – Predated *Parablennius pilicornis* eggs.

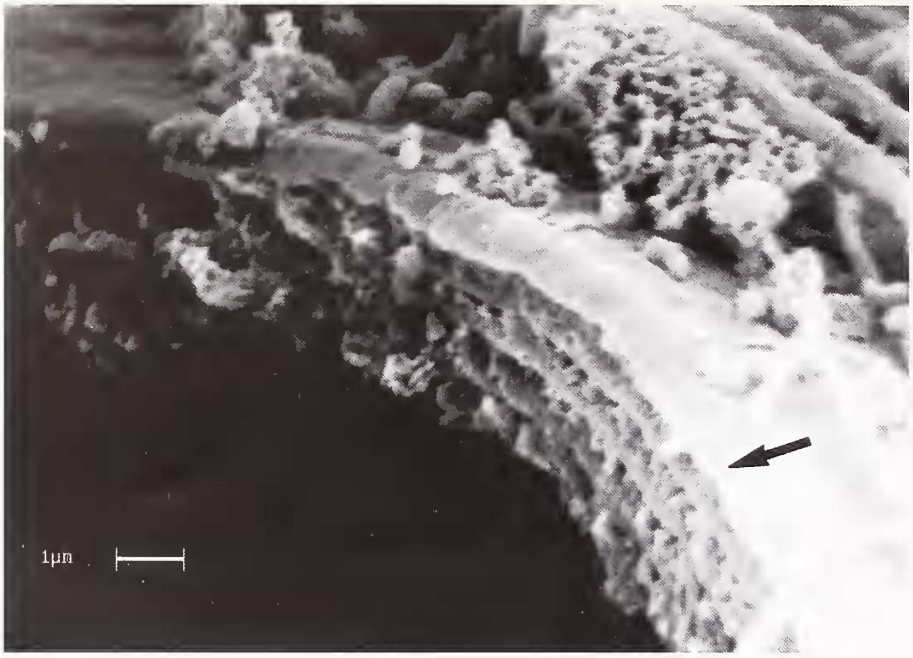

Fig. 5 - Detail of the incision in the egg membrane. Arrow indicates outer border.

immediately before suction the animal usually bends forwards all its cerata, letting them return to the "normal" position after the actual suction begins. The opening of the egg membrane was observed to be a quick task. If by any chance the egg already contains an embryo, it is apparently crushed during suction process, as we see it into small pieces. The procedure above is repeated with a succession of eggs, until the animal is satiated, leaving behind a variable band of empty egg membranes. Under laboratory conditions we observed up to 30 eggs being continuously consumed, in less than one hour, by a single adult individual.

SEM images of empty fish egg membranes (figs. 4 and 5) allow us to see the size and shape of the opening made by the mollusc. It clearly shows evidence of radular action as discussed below.

DISCUSSION

Erosion on the outer border of teeth, on the serrated portion of the radula, made us believe that these teeth are functional, regardless of their small size (as compared with those of other aeolidaceans). Examination of fish egg membranes after consumption seems to agree with this view. Moreover, there is a reduced radula size difference between animals having a markedly different body length, making us suspect that the entire "adult-like" radular morphology is developed early in the ontogenetic process. In fact we have observed smaller animals feeding in a manner similar to larger ones.

Therefore, one can assume that juveniles already feed on fish eggs, contrarily to the previous assumption that juveniles are general carnivores (EVANS, 1922). Thus, there seems to be no food size constraint.

Terminal larger teeth seem to continue differentiating, from the juvenile phase onwards, making us believe that they may also be useful for the adult's feeding behaviour. EVANS (1922) suggested that these teeth might be used only in the post-settlement phase, before juveniles could find fish spawn.

SEM images of empty fish egg membranes show openings, made by the molluscs, that are consistently regular as if cut with a "surgical" instrument and not just torn open. The openings observed were morphologically identical and suggest a sawing-like method of cutting, precise and efficient. The observation of living animals while feeding also indicates that this procedure is a rapid one. We conclude that the saw-like portion of the radular tooth is used to cut open the membrane with a minimum effort allowing its inner content (which may contain hard parts, if fish's larva is already formed) to be extracted.

ACKNOWLEDGEMENTS

This work was carried out while first author was holder of a grant from "Fundação para a Ciência e Tecnologia"- Portugal (PraxisXXI/BD/11185/97). We thank Ilídio Félix-Alves (I. P. M. – Portugal) for his critical review of the English version of the text. We also acknowledge Dr. J.L. Cervera, editor of this special issue, and two anonymous referees, whose comments and criticism helped to improve the current version of the paper.

REFERENCES

EVANS T. J., 1922. *Calma glaucoides*: a study in adaptation. *Quarterly Journal of Microscopical Science*, London, 66: 439-455.

HUGHES R.N. & EMERSON W. K., 1987. Anatomical and taxonomic characteristics of *Harpa* and *Morum* (Neogastropoda: Harpaidae) *The Veliger*, Berkeley, 29: 349-358.

ROWETT H.G.Q., 1946. A comparison of the feeding mechanisms of *Calma glaucoides* and *Nebaliopsis tipica*. *Journal of the Marine Biological Association of the United Kingdom*, Plymouth, 26: 352-357.

Lavoro accettato 7 febbraio 2000